#14 Declaration
SMW/12-5-03

OIPE JC106
NOV 17 2003
PATENT & TRADEMARK OFFICE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of: **DeSALVO ET AL.**	Examiner: H. Phan
Serial No. **09/724,256**	
Filing Date: **November 28, 2000**	
Confirmation No. **7913**	Art Unit: 2633
For: **OPTICALLY AMPLIFIED RECEIVER**	

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DECLARATION UNDER 37 C.F.R. 1.131

Mail Stop Non-Fee Amendment
Commissioner for Patents
P. O. Box 1450
Alexandria, VA 22313-1450

Sir:

We, **JOHN DeSALVO, MICHAEL LANGE, SCOTT BRICKER, RANDALL K. MORSE and JANE CLAIRE WHITE**, hereby declare:

1. We are the joint inventors of claims 1-31 of U.S. patent application serial no. 09/724,256 identified above, and the subject matter described and claimed therein.

2. Prior to September 30, 1998, the effective date of cited U.S. Patent No. 6,384,948 to Williams et al., we had conceived our invention that is described and claimed in the above-identified patent application while working in the United States in the Palm Bay, Florida facility of Harris Corporation. We worked diligently on developing the claimed invention from the time of conception to reduction to practice at a date before September 30, 1998. From the time of reduction to practice to the filing of the above-identified

patent application, we worked diligently on developing a commercially feasible optically amplified receiver of the present invention.

3. Before September 30, 1998, joint inventors, Randall K. Morse and Jane Claire White, had initially worked on the development of a structure and circuit for optically amplifying signals to deliver a clean current source through an injection laser diode as part of an optically amplified receiver that optimizes a system and is incorporated into a single assembly. Joint inventors, Morse and White, were later joined by joint inventors, DeSalvo, Lange and Bricker, before September 30, 1998 to design an improved optically amplified receiver based upon the initial research of joint inventors, Morse and White.

4. Before September 30, 1998, we conceived an optically amplified receiver using an optical preamplifier, bandpass filter, PIN detector and amplifier circuit. Initial conception drawings are shown in the laboratory notebook sheets 1 and 2 of Exhibit 1 attached hereto. Pages 3-7 of this exhibit also show the development and the initial conception of the optically amplified receiver. As evident, it includes an optical preamplifier for receiving an optical communications signal over a fiber optic communications line. The bandpass filter receives the signal and selects the signal channel and filters out noise. A PIN detector receives the optical communications signal from the bandpass filter and converts the optical communications signal into an electrical communications signal. An amplifier circuit amplifies the electrical communications signal. Sheet 7 shows a technical memorandum that was written by one of the joint inventors.

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Filing Date: **11/28/2000**

5. The joint inventors worked diligently to reduce to practice this invention and tested the invention as shown by the receiver sensitivity experiment on sheet 8 of the laboratory notebook in Exhibit 1 before the September 30, 1998 effective date of the Williams et al. reference.

6. The dates are deleted on the sheets from Exhibit 1 and all dates are prior to September 30, 1998.

7. We hereby declare that all statements made herein of our own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

11/7/2003
Date

JOHN DeSALVO

11/6/03
Date

MICHAEL LANGE

11/6/03
Date

Scott Bricker
SCOTT BRICKER

11-6-03
Date

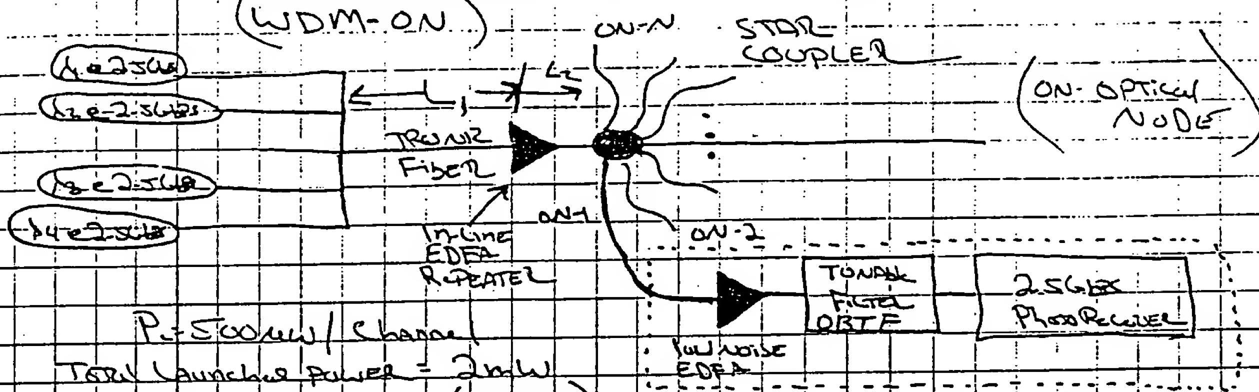
Randall K. Morse 11-6-03
RANDALL K. MORSE

11-6-03
Date

Jane Claire White
JANE CLAIRE WHITE

Low-Noise WDM Receiver

Wavelength-Division Multiplexer Optical Network (WDM-ON)



P = 500uW / Channel

Total Launch power = 2mW (+3 dBm)

L1 - Fiber Span to first Repeater EDFA (Assume 50 km spans) $\alpha L = (0.2\,dB/km)(50)$ $(\alpha L = 10\,dB)$

L2 - Fiber length between Star Coupler and EDFA Repeater ($L_2 \ll L_1$)

1x64 STAR COUPLER	- 18 dB Loss	Fixed	-18 dB
L_{ex}	-2 dB	excess optical loss per span x2	-4 dB
L_{scx}	-0.5 dB	excess STAR coupler insertion loss	-0.5
L_{bp}	-2.0 dB	OBTF insertion loss	-2.0
			-24.5 dB

The WDM Receiver is capable of accepting multiple optical channels on a single fiber, amplifying them and either choosing a single channel as shown above, or demultiplexing them into individual channels for simultaneous reception. The optical amplifier is used to provide high sensitivity, probably better than any APD.

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[signature]

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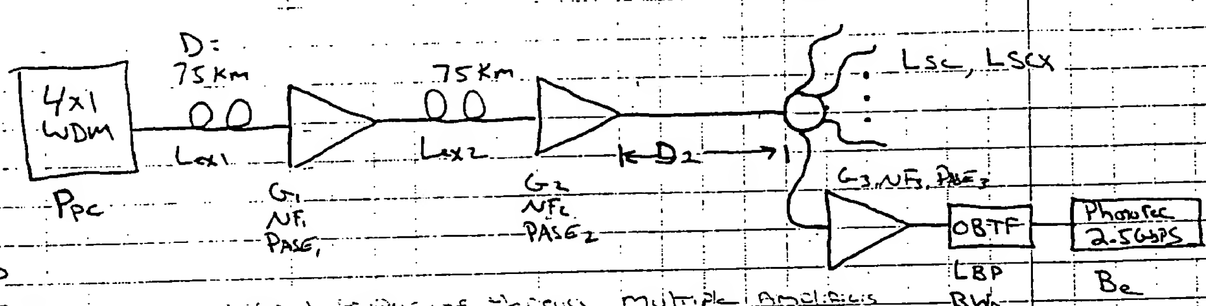
POINT-TO-POINT WDM LINE ANALYZED



P_{PC} - AVG. I/P OPTICAL POWER PER WDM chan.

L_{ex} = excess loss PER SPAN

D = FIBER SPAN between REPEATERS

Signal propagating through multiple amplifiers seems to build the noise background

1) $P_{ASE} = N_{SP}[G-1]\,h\nu B_o$

2) TOTAL ASE POWER OUT OF 2nd In-line EDFA

$P_{SPT} = P_{ASE2} + P_{ASE1}\,e^{-\alpha D} + e^{\alpha D} + L_{ex}$

$C = .5(1-10^{-\frac{\alpha L}{10}})$

$-19.4\,dB$

$D_2 \leq D/2$ (Bounding PARAMETER)

$L_1 = e^{-\alpha D}$, $\alpha = 0.2$ dB/Km } FIBER ATTENUATION LOSS-S

$L_2 = e^{-\alpha D_2}$

$L_{SC} = -10 * \log_{10}[N_U]$, N_U = # OF USERS FOR STAR COUPLER

L_{SCX} = EXCESS loss in STAR COUPLER

- In-line Amplifiers compensate only for Fiber Attenuation loss $\Rightarrow G = e^{\alpha D_x}$ Therefore, the Signal Power Out of the EDFA is equal to its value at the beginning of the span.

- Routing Loss is defined as the total loss to the signal that occur immediately following the last in-line EDFA in addition to the excess losses occuring in the trunk lines that are not compensated by the in-line EDFA gain.

$$L_R = L_{ex} + e^{-\alpha D_2} + L_{SC} + L_{SCX}$$

- There is one last loss element between the EDFA Preamplifier and the Photodetector, the tunable optical bandpass filter, LBP

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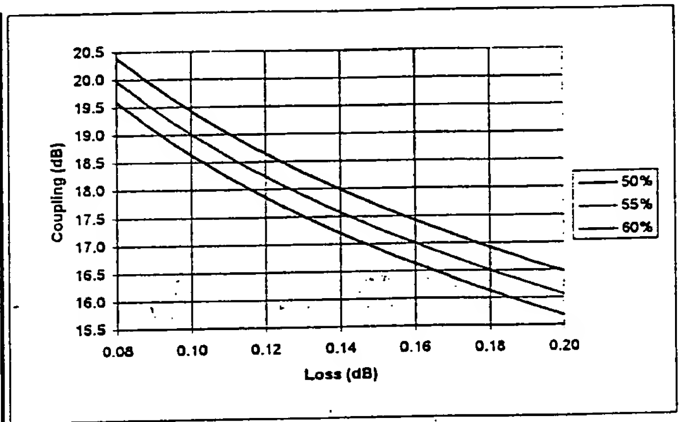
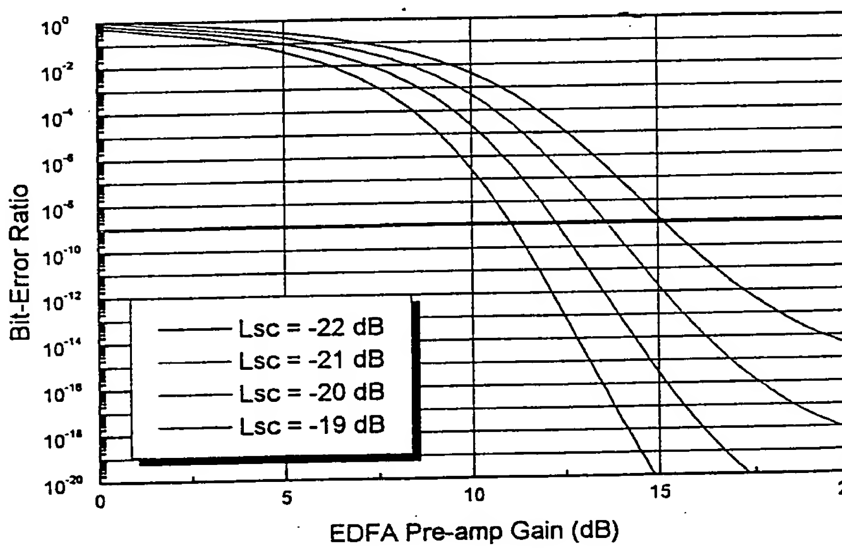
LAUNCED POWER PER CHANNEL - 6dBm (250 uW)

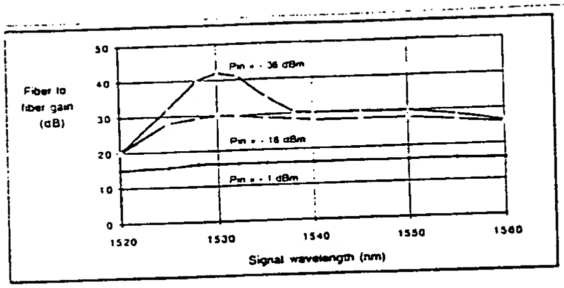
Loss (dB)	Coupling @ CE=50%	Coupling @ CE=55%	Coupling @ CE=60%
0.080	20.4	20.0	19.6
0.085	20.1	19.7	19.3
0.090	19.9	19.5	19.1
0.095	19.7	19.2	18.9
0.100	19.4	19.0	18.6
0.105	19.2	18.8	18.4
0.110	19.0	18.6	18.2
0.115	18.8	18.4	18.0
0.120	18.7	18.2	17.9
0.125	18.5	18.1	17.7
0.130	18.3	17.9	17.5
0.135	18.2	17.7	17.4
0.140	18.0	17.6	17.2
0.145	17.8	17.4	17.1
0.150	17.7	17.3	16.9
0.155	17.6	17.1	16.8
0.160	17.4	17.0	16.6
0.165	17.3	16.9	16.5
0.170	17.2	16.8	16.4
0.175	17.0	16.6	16.3
0.180	16.9	16.5	16.1
0.185	16.8	16.4	16.0
0.190	16.7	16.3	15.9
0.195	16.6	16.2	15.8
0.200	16.5	16.1	15.7

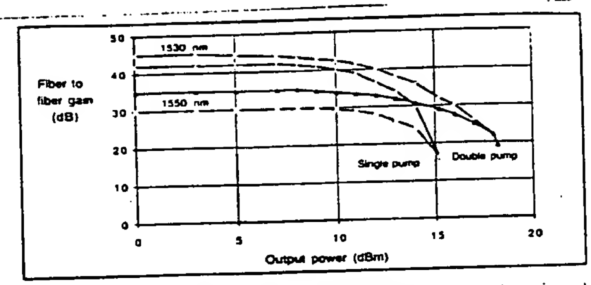




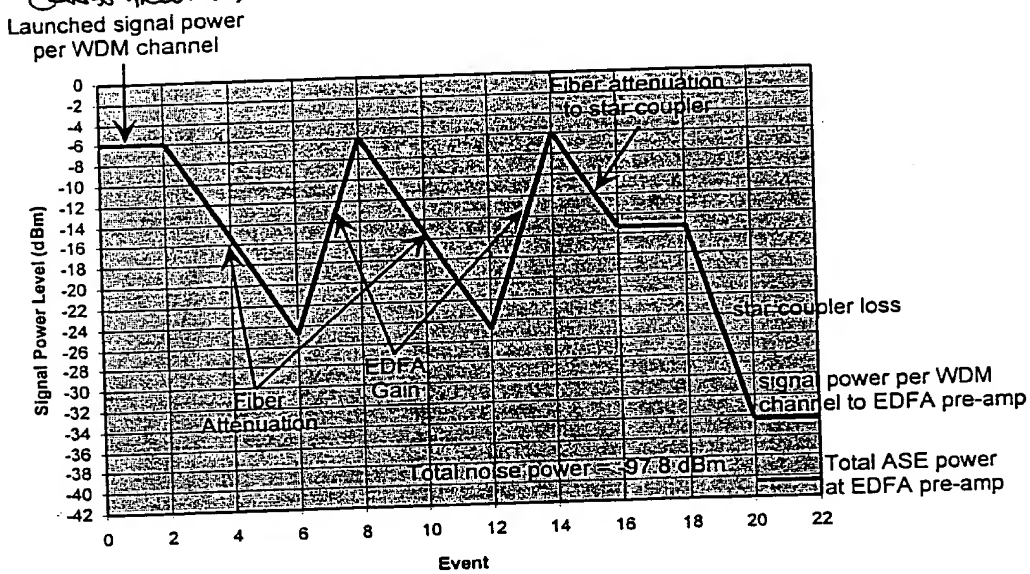
The condition/Assumption used in the analysis are:

- Lex=0, the in-line amplifier compensate for any cell loss that occur in a span
- L_1 = -18.75 dB ⇒ the in-line EDFA must provide at least 18.75 dB of gain per WDM channel. The noise figure of the in-line EDFA was fixed at 5.5dB
- D2, the maximum distance the STAR coupler can be placed from an in-line EDFA is D1/2, therefore, the signal level (i.e. the launched power per channel) will drop by 9.4 dB (No more than).
- WDM signal is distributed to the optical nodes via a 64 channel STAR coupler with loss, Lsc = -18 dB. Excess losses (coupler efficiency) are to be assumed in the 1 to 3 dB range
- A representation of the system power budget showing the signal power level per WDM channel at the EDFA pre-amp input is shown on the next page.

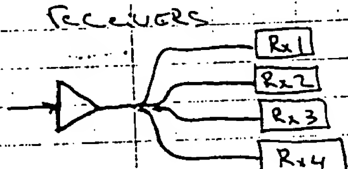


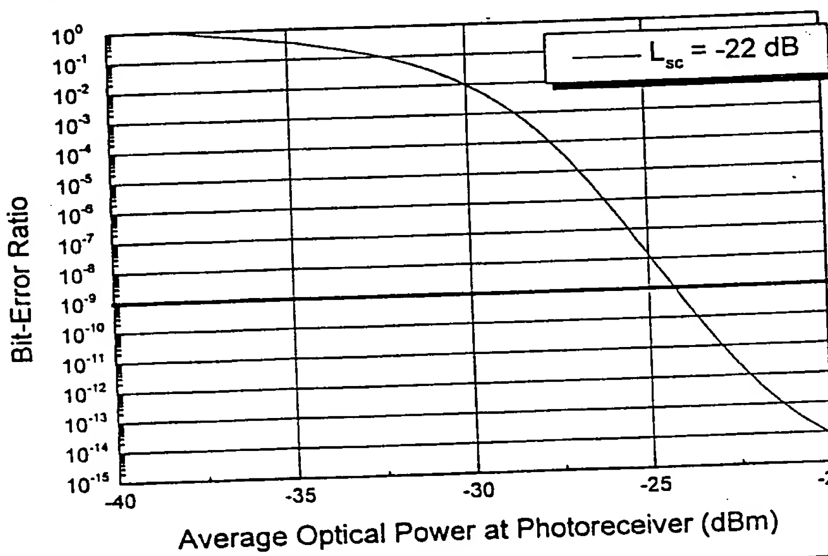


Graphical Representation of WDM System Power Budget



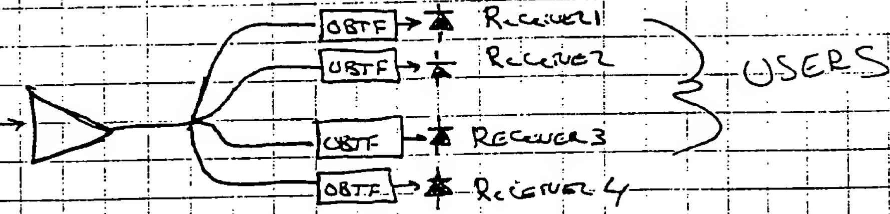
To simultaneously recover the 4 WDM signals, the optical signal out of the EDFA preamp must be split 4-ways to individual receivers



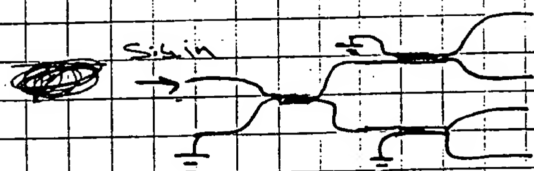


We'll ~~adopt~~ use the worst-case coupling loss of -22 dB for this analysis trading the de-multiplexing topology, EDFA pre-amp gain, and the addition of another EDFA used to compensate for the additional splitting losses if the pre-amp gain alone is not adequate

Power Splitter / Optical Bandpass Tunable Filter De-multiplexer



Power Splitter: Cascaded 3-dB Couplers



Minimum Insertion Loss = −6 dB
Typical IL = −7 dB

OBTF characteristics are the same as in the analysis, i.e. approx 2 dB insertion loss and tunability over the input signal wavelength range. Assume the loss is independent of ~~the~~ center wavelength.

ADVANTAGES

- Variable Signal Wavelength
  - Reconfigurable Network
  - Add/Drop Multiplexing
- User ~~Selectable~~ Selectable Signal band
  - WDM distribution Network

DISADVANTAGES

- Lossy

For 20 dB Preamp gain, including a power splitter w/ −7 dB insertion loss would result in a ~~[illegible]~~ $BER = 3 \times 10^{-6}$

To achieve a minimum $BER = 10^{-9}$, the EDFA pre-amp gain would only need to be increased to $G = 22.2$ dB

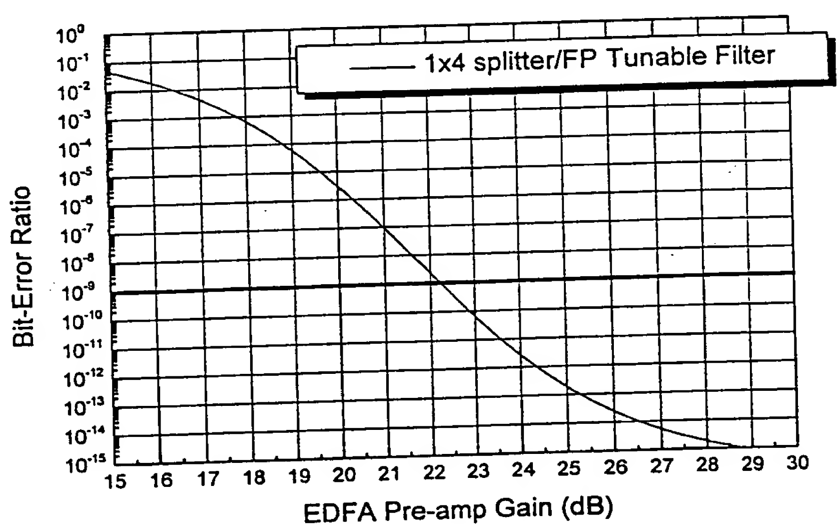
SEE PLOT ON FOLLOWING PAGE

Tunable Fabry-Perot Etalon Filter

		Oper. λ	FSR	BW	F	IL
JDS Fitel	TB2500M	1520-1570	50-85	.4-.9	100	<2.5
	TB2500-CB Tracking Filter	"		.2-1.0	40-100	<5
	TB2500-EC Controller Unit					

Micron Optics In-line Fiber FP filters Total loss <2 dB

Santec



Electrical Power Dissipation Issue
- Phoned Olivier Guy @ Photonetics (617) 245 2333
- Gave him Lucent's spec. values for a compatible amplifier
- Will fax France to ask about reducing the dissipated electrical power

See PAGE 88 Regarding Fax-back from France

7-144

Technical Memorandum
JA 4139-0301

Title: Sensitivity Calculation for an EDFA Pre-Amplified pin Photodetector Receiver

Author: Richard DeSalvo

1.0 Introduction

This memo summarizes the analysis performed in calculating the receiver sensitivity for an erbium-doped fiber optical pre-amplifier and pin photodetector. The receiver is assumed to operate at 2.488 Gb/s. The EDFA is modeled after the OptiGain Model 4012 optical pre-amplifier and the receiver module is modeled after the Sumitomo SDT 8908-R-Q fiber optic receiver module. The analysis is based on Chapter 3, "Photodetection of optically amplified signals," in Desurvire's Erbium-Doped Fiber Amplifiers - Principles and Application. A block diagram describing the components modeled and their appropriate parameters is shown in Figure 1.

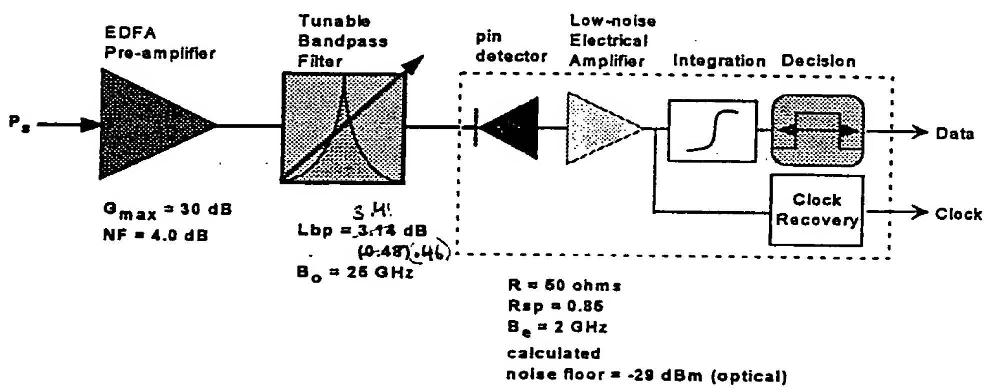


Figure 1 Block diagram representation of an OPA + D receiver with parameters used in the sensitivity model presented.

Reviewed to practice

Receiver Sensitivity Experiment

Photonetics EDFA

Calculate $\overline{P} = -40.8$ dBm

Theoretical $\overline{P} = -47.1$ dBm

$G_{ss} =$ ~~25~~ 27 dB, NF = 4.5 dB

O/P coupling loss ~~[illegible]~~

OTF $B_{W} = 25$ GHz

IL = 4.92 dB

$B_e = 2$ GHz   NP = -24 dBm

$K_{ol} = 13$ dB

Measured $\overline{P} = -39.7$ dBm

Using Optigain EDFA, we measure a Receiver Sensitivity $\overline{P} = -41.5$ dBm

$$-41.5\text{ dBm} = \frac{\cancel{2.818}\ 7.08 \times 10^{-8}\ W\left(\frac{J}{Sec}\right)}{h\nu (J)} = \frac{\#\ \text{Photons}}{\text{Sec}}$$

$$h\nu = \frac{hc}{\lambda} = \frac{6.626\times10^{-34}\ J\cdot Sec \cdot 3\times10^{8}\ m/s}{1550\times10^{-9}\ m} = 1.28\times10^{-19}\ J$$

$$= \frac{\cancel{2.2}\ 5.5 \times 10^{11}\ \text{Photons/Sec}}{2.488\times10^{9}\ b/s} = \cancel{88}\ 222\ \text{Photons/Sec}$$

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